TECHNICAL REPORT

# MID-LEVEL ASSESSMENT:

## CLIMATE FORECASTING IN KAZAKHSTAN

**OCTOBER 2014**

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Engility Corporation Contact:
Glen Anderson, Chief of Party, Glen.Anderson@EngilityCorp.com
Engility Corporation
1320 Braddock Place
Alexandria, VA 22314

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October 2014

Prepared for:

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Global Climate Change Office, Climate Change Resilient Development project

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*and*

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International Research Institute for Climate and Society

Palisades, NY

Prepared by:

Glen Anderson, Senior Manager

Yoon Kim, Former Manager

Engility/International Resources Group

Alexandria, VA

Contact: Michael E. Cote, Engility Corporation, Michael.Cote@EngilityCorp.com

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# ACRONYMS

| | |
|---|---|
| CCRD | Climate Change Resilient Development |
| CRW | Climate Resilient Wheat Project |
| CSP | Climate Services Partnership |
| IRI | International Research Institute for Climate and Society (Columbia University) |
| NDVI | Normalized Difference Vegetation Index |
| SPI | Standardized Precipitation Index |
| SSMI | Special Sensor Microwave Imager |
| UNDP | United Nations Development Programme |
| USAID | U.S. Agency for International Development |
| USAID/CAR | USAID Mission for Central Asian Republics |
| WMO | Word Meteorological Organization |

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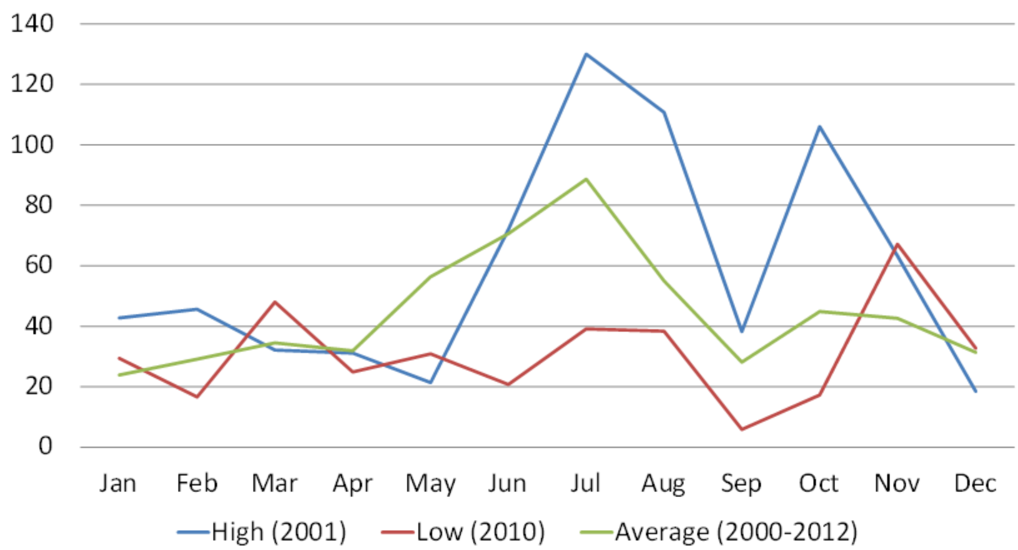
# 1. INTRODUCTION

Kazakhstan is the ninth largest producer and seventh largest exporter of wheat in the world. With almost half of its exports destined for buyers in Central Asia, Kazakhstan has an important role to play in regional food security. However, Kazakhstan faces many challenges in increasing or even sustaining productivity. The wheat sector is still evolving from a Soviet-style farming system to a "corporate" model featuring advanced cultivation methods, diversified cropping, and utilization of efficient and appropriate technologies and chemical applications. One of its greatest challenges relates to climate variability. Exhibits 1 and 2[1] illustrate the annual and monthly variability in precipitation in two of the three spring wheat regions in Kazakhstan while Exhibit 3[2] displays the results of climate variability in terms of annual wheat yields.

In 2012, the United States Agency for International Development (USAID) Regional Mission for Central Asian Republics (USAID/CAR) was awarded a $1.1 million integration pilot to help the wheat sector respond to climate variability and change. The project, referred to as Climate Resilient Wheat (CRW), is implemented by the United Nations Development Programme (UNDP) Project Office in Astana with support on adaptation planning and climate services from the USAID-funded and Washington, DC-based Climate Change Resilient Development Project (CCRD). This report focuses on the assessment of weather and climate services in Kazakhstan that has been conducted over the last year. These services are viewed as an important source of information for farmers in making annual decisions on the crop calendar, mainly when and what to plant.




*Excludes Burabai, Novomarkovka, Shortandy, Stepniak, and Zerendy due to lack of data

**Figure 1: Monthly Precipitation (mm.)**
**Akmola Oblast, Kazakhstan (2000-2012)***

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[1] Data provided by the National Hydrometeorological Service (Kazhydromet)

[2] United States Department of Agriculture (USDA), Foreign Agriculture Service, 2014. Wheat production in Kazakhstan [online]. USDA: Washington, D.C. Available at: < http://www.fas.usda.gov/pecad2/highlights/2005/03/Kazakh_Ag/> [Accessed January 23, 2014].

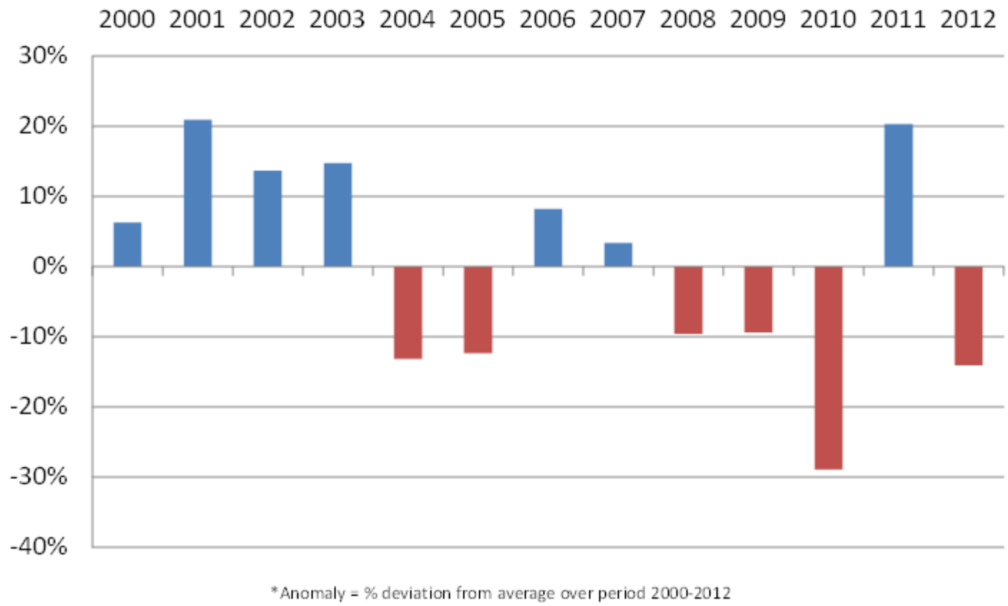


**Figure 2: Annual Precipitation Anomaly* (%)**
**Kostanay Oblast, Kazakhstan (2000-2012)**

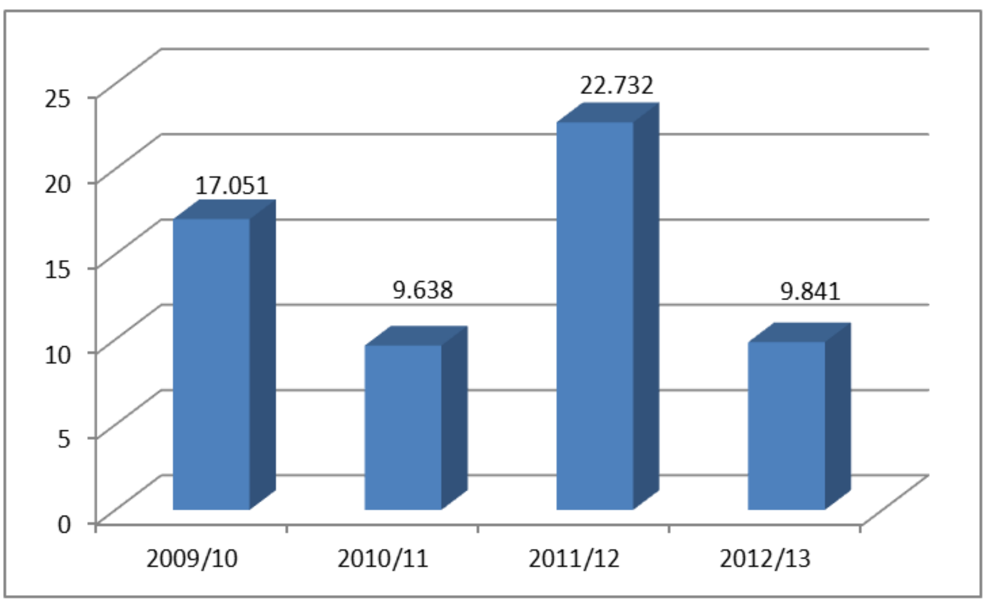


**Figure 3: Wheat production (million metric tons) in Kazakhstan from 2009/10-2012/13**

## 1.1. AIMS OF THE EVALUATION

The goal of this mid-level evaluation is to identify opportunities to strengthen the capacity of the Kazakhstan National Hydrometeorological Service (Kazhydromet) and the National Space Institute to develop and disseminate forecasting products for the spring planting in Northern Kazakhstan. The focus is on products that support farmers' decisions of when to plant spring wheat in particular and on the selection of wheat varieties and/or alternative crops such as other cereals, oilseeds, and legumes.

## 1.2. ASSESSMENT METHODS

This evaluation of current weather and climate services employed a combination of methods, including stakeholder consultations, self-assessments by service providers and an independent assessment of weather and climate services commissioned by CRW.[3] Stakeholder processes have included:

- Meetings with national-level stakeholders during inception meetings for CRW (November-December 2012)
- Stakeholder workshops in Astana, Shortandy, Kostanay, and Petropavlovsk (February-March 2013)
- Informal survey of farmers who attended the CRW "field days" in August 2013 (conducted by UNDP)

In May 2013, CRW convened the Climate Services Roundtable in Almaty. This two-day workshop featured self-assessments presented by the two primary providers of services – Kazhydromet and the National Space Institute – plus a presentation on agricultural extension services provided by Kazagroinnovation. Three US-based experts participated in the Climate Services Roundtable, provided comments and feedback on the Kazakh presentations, and made presentations on international practices related to monthly and seasonal forecasting, drought indexes, and remote sensing products.

## 1.3. ROADMAP

Section 2 presents the problem diagnosis of climate services in Kazakhstan. The value chain framework is used to describe the linkages between the development of climate services and crop production. In addition to describing the two value chains, Section 2 examines the weaknesses in the current suite of climate services and the needs of users elicited through consultations and the survey of farmers who participated in the CRW field days. Section 3 describes opportunities for improving climate services, and Section 4 identifies constraints that will need to be overcome for the wheat sector to utilize climate services effectively.

[3] Baisholanov, S., 2013. *Agrometeorological Support of Agriculture of the Republic of Kazakhstan,* Report prepared for UNDP/USAID Project "Improving the Climate Resiliency of Kazakhstan Wheat and Central Asian Food Security." UNDP and USAID: Astana, Kazakhstan.

# 2. PROBLEM DIAGNOSIS

Exhibit 4 illustrates the value chains for climate services and wheat production. They are called value chains because the activities summarized in each box (link) add value to the final product. The problem diagnosis on improving climate services presented in this section first describes the production of climate and weather information as well as crop yield estimates. The role of these information products is examined in the context of the crop production value chain. The section concludes with a discussion of the weaknesses in the information products that may limit their role in decision-making and contribution to the value of the final products) produced in the value chain.

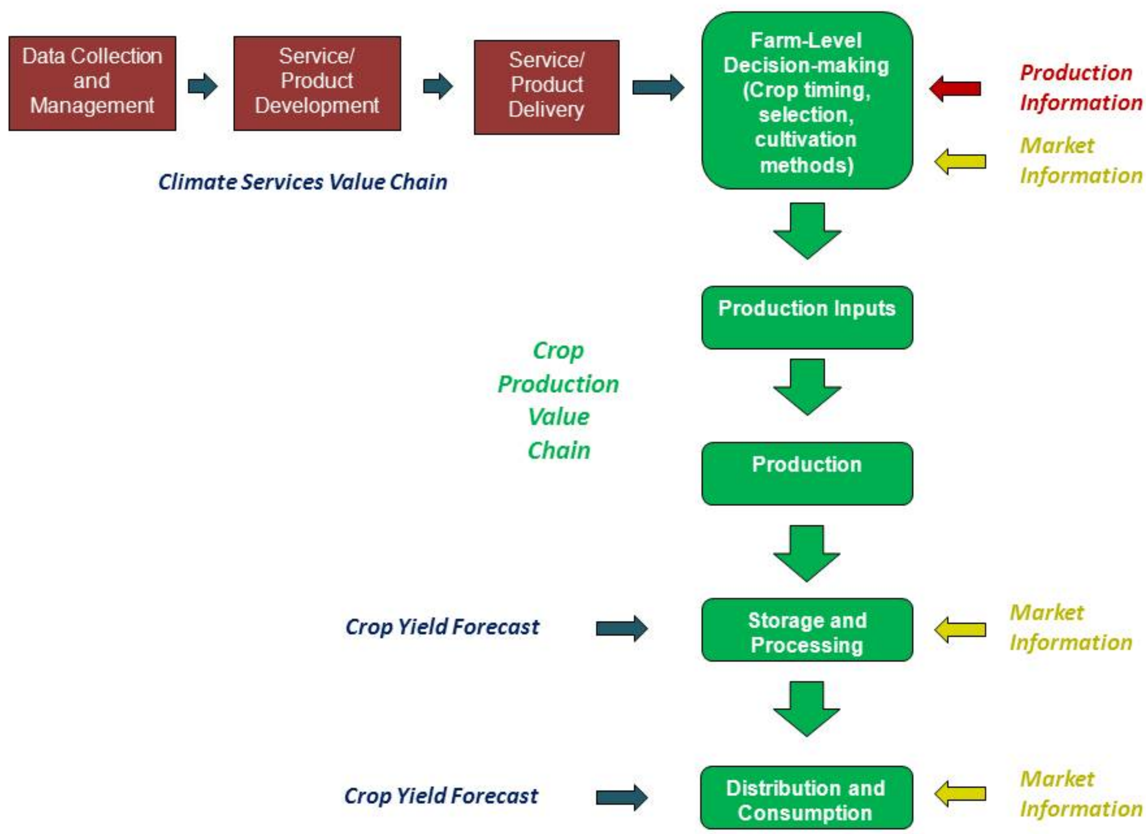


**Figure 4: Value chains for the production of climate services and wheat production**

## 2.1. PRODUCTION OF CLIMATE SERVICES IN KAZAKHSTAN

The production of weather and climate services involves three steps: data collection and management, service/product development, and service/product delivery. In Kazakhstan, Kazhydromet is responsible for the production of weather and climate services. Kazhydromet is a state owned enterprise under the Ministry of Environmental Protection, with 3,500 staff, including 210 based in its headquarters in Astana. It is responsible for monitoring meteorological and hydrological conditions in Kazakhstan and provides forecasts to the Ministries of Agriculture and Emergency Situations. Kazhydromet agro-meteorologists are also tasked under the mandatory crop insurance law with certifying the occurrence of adverse natural events such as droughts, storms, frost, and hail that damage crops. Kazhydromet is primarily government-funded, and receives payment from the Ministry of Agriculture of KZT 22 million or $150,000 for the development of weather and climate information for farmers.[4] It also has a revenue stream based on sales of data to the private sector.

### 2.1.1. DATA MONITORING AND MANAGEMENT

Kazhydromet operates 287 meteorological stations, 90 of which are automated, and 13 meteorological posts. Stations have a staff of five people; these include a meteorologist with a Bachelor's degree and three individuals to gather data, with rotating duties to ensure collection throughout the day. In agro-meteorological stations, the fifth staff member is an agricultural specialist and, in some cases, takes on extension responsibilities. Posts are managed by one staff member.

At manually operated stations, which constitute nearly 70% of Kazakhstan's existing network, meteorological observations are collected by a technician eight times daily (every three hours). They include measurements of temperature, air humidity, wind characteristics, atmospheric pressure, soil temperature, visibility, height of the cloud base, and number and shape of clouds. When there is snow cover, measurements of snow depth and characterization of its nature are conducted daily, and snow surveys on established routes are carried out every ten days. At the automated stations and posts, measurements of temperature, air, humidity, atmospheric pressure, wind speed and direction, amount and intensity of rainfall, and duration of sunshine are collected hourly. Cloud cover and snow depth are also determined manually at automated stations.[5]

Within Kazhydromet, the Meteorology Department provides quality control for the digitization of the meteorological record. The Climatology Department conducts statistical analysis and data processing, develops client-specific products, and generates periodic climate bulletins for ministries upon request. It also sells quality controlled station level data from the observational network, primarily to private companies in sectors such as mining, energy, and transport (e.g., railroads). The Department makes approximately $7,000 a month through the provision of this information. The Agro-Meteorology Department archives and provides quality control of the data received in hard copy from agro-meteorological stations throughout Kazakhstan.[6]

Agro-meteorological monitoring is conducted at 202 posts, with 115 of these meteorological stations and 87 agro-meteorological posts. Sixteen of the 87 agro-meteorological posts are automated. Observations on plant growth are conducted by 90 meteorological stations and 87 agro-meteorological posts, and on cattle breeding by 25 meteorological stations.[7] There are also 295 hydrological stations measuring stream flow and levels.[8]

Agro-meteorological information relevant for plant growth is collected through stationary observations and ground route surveys. Agricultural crop observations are recorded at 177 stations/posts. At meteorological stations, these observations are carried out in parallel to meteorological observations at sites that are selected annually in the spring and are located in fields, gardens, melon fields, pastures, hay fields, and orchards. In addition to phenological observations, a limited set of meteorological data (maximum and minimum air temperature and precipitation) is gathered twice daily at agro-meteorological posts. Agro-meteorological posts

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[4] Anderson, G., 2012. *Trip Report, Astana, Kazakhstan TDY Mission, November 26-December 7, 2012,* Memorandum prepared for CCRD. CCRD: Washington, D.C.

[5] Baisholanov, S., 2013. *Agrometeorological Support of Agriculture of the Republic of Kazakhstan,* Report prepared for UNDP/USAID Project "Improving the Climate Resiliency of Kazakhstan Wheat and Central Asian Food Security." UNDP and USAID: Astana, Kazakhstan.

[6] Zermoglio, F., 2013. *Trip Report, Almaty and Astana, Kazakhstan TDY Mission, September 22-October 2, 2013*, Memorandum prepared for CCRD. CCRD: Washington, D.C.

[7] Baisholanov, S., 2013. *Agrometeorological Support of Agriculture of the Republic of Kazakhstan,* Report prepared for UNDP/USAID Project "Improving the Climate Resiliency of Kazakhstan Wheat and Central Asian Food Security." UNDP and USAID: Astana, Kazakhstan.

[8] Anderson, G., 2012. *Trip Report, Astana, Kazakhstan TDY Mission, November 26-December 7, 2012,* Memorandum prepared for CCRD. CCRD: Washington, D.C.

do not measure or observe average air temperature, cloud cover, and weather phenomena, due to limited staffing of one technician per site. Measurements of productive moisture reserves in the top meter of soil are collected at 123 stations/posts (90 meteorological stations, 33 agro-meteorological posts). Exhibit 5 summarizes the agro-meteorological variables that are observed.[9]

| Season | Observed variable |
|---|---|
| Spring | • Soil temperature on a major field for planning the leading agricultural crop<br>Topsoil moisture |
| Summer (growing season) | • Onset of the main phases of plant development and their condition<br>• Height and thickness of the haulm strand<br>• Productivity elements<br>• Soil moisture: Productive moisture in the 0-20 cm, 0-50 cm, and 0-100 cm of soil layers, moisture content of agricultural crops |
| Autumn | • Topsoil moisture |
| Winter | • Height and nature of the snow cover |
| General | • Damage to crops by adverse weather phenomena |

**Table 1: Agro-meteorological observations by season**

In addition to stationary observations, ground route surveys are also conducted to fill gaps in the coverage of agricultural areas by the existing network of stations/posts. Forty-eight route surveys are conducted in eleven regions of Kazakhstan. Full programs encompass two routes to evaluate soil productive moisture at the beginning and end of the growing season, and two phenological routes during the onset phase of crop ear emergence to assess plant height and density, appearance, extent of chemical residues in soil, and damage by pests and diseases. Shortened programs only include one phenological route. Full agro-meteorological route surveys are conducted in Akmola, Kostanay, North Kazakhstan, Pavlodar, Karaganda, West Kazakhstan, and East Kazakhstan oblasts (provinces), and shortened route surveys in Aktobe, Zhambyl, Almaty, and South Kazakhstan.[10] Also, six route observations are conducted in wheat grain crop fields in spring and autumn in Almaty, Zhambyl, and South Kazakhstan oblasts.[11]

Observational data from meteorological stations are encoded manually every three hours, at the end of each month, and at the end of each decade. Data from agro-meteorological posts are encoded manually at the end of ten-day period. Meteorological stations transmit data via email, telephone, radio, and cellular connection to the oblast hydrometeorology center, which then conveys this information to Kazhydromet via email.

Automated meteorological stations generate portions of their data transmittal telegrams automatically. However, certain visual observations are recorded manually. Automated stations also send data on basic meteorological parameters on an hourly basis to the province's hydrometeorological center and to the Kazhydromet Information Center.

[9] Baisholanov, S., 2013. *Agrometeorological Support of Agriculture of the Republic of Kazakhstan,* Report prepared for UNDP/USAID Project "Improving the Climate Resiliency of Kazakhstan Wheat and Central Asian Food Security." UNDP and USAID: Astana, Kazakhstan.

[10] *Ibid.*

[11] Iskakov, Y., 2013, May. Agrometeorological monitoring technology on agrometeorological forecast development provision of Kazakhstan's AIC with analytical and forecasting information. Presentation at given at "Roundtable on the Provision of information and Services on Weather and Climate", Almaty, Kazakhstan.

The meteorological record in Kazakhstan goes back to the 1840s; 80% of stations have at least 30 years of records. The Meteorology Department has been digitizing the historical record from the country's meteorological stations up to 1998, and has already digitized 200 years of data. It is important to note that the digitization effort has been focused on addressing the backlog of historical records, and so much of the data from 1998 onward will need to be digitized at a later time. The Meteorology Department is currently using the meteorological information management system software PersonaMis to develop the archive.

The Climatology Department examines long-term climatology, using the xml based Cliware software system, and develops products in response to client requests. The department receives a minimum of 5-10 weekly requests on specific stations, regions, and variables from public and private entities. The data generated by the Climatology Department is sold through the Marketing Department.

The Agro-meteorological Department translates the monthly coded messages sent by agricultural stations into hard copy record books. These are stored in the Department and include observations on crop growth, development phases, yields, weeds, and density. The records have not been evaluated to identify and understand changes in the variables over time.

### 2.1.2. SERVICE/PRODUCT DEVELOPMENT

Kazhydromet produces weather and agro-meteorological forecasts, decadal agro-meteorological reviews, and analytical materials requested by individual farms (primarily on current and expected soil moisture). Forecast products include short-term forecasts (1-day and 3-day) and long-term forecasts (10-day, monthly, and seasonal) for temperature and precipitation.[12] To develop its seasonal and monthly forecasts, Kazhydromet uses an analogue method, rather than a numerical forecast.[13] Analogue methods consider similar historical trends to predict weather. Moreover, these forecasts are developed manually, with hard copy books used to identify the analogues. The forecast is prepared as a combination of three outcomes (normal, below normal, and above normal) with probabilities assigned to each outcome. For example, the monthly forecast for precipitation might be reported as: 40% probability of precipitation above normal; 40% probability of normal precipitation; and 20% probability of precipitation below normal.

For its short-term forecasts, the daily forecast operations center uses basic numerical modeling and translates one to three hour reports into products that are either made available free of charge on Kazhydromet's website (one-day) or sold (three-day).

Kazhydromet also provides agro-meteorological forecasts to the Ministry of Agriculture on the following:

- Soil moisture reserves during the period of spring field work
- Timing of ripening of spring crops
- Optimal sowing times for spring crops
- Agro-meteorological conditions during the period of crop harvest (advisory forecast).

In addition to the forecasts prepared by Kazhydromet, the National Space Institute provides a snow melt forecast and estimates soil moisture using an alternative methodology that draws on remote sensing information. Kazhydromet also prepares ten-day bulletins for the Ministry of Agriculture on crop growth, pest levels, soil temperature and moisture.

[12] Akisharas, G., 2013, May. Long-term weather forecast management. Presentation given at "Roundtable on the Provision of information and Services on Weather and Climate", Almaty, Kazakhstan.

[13] *Ibid.*

In terms of the usefulness of the weather and climate information that Kazhydromet provides, it is not clear whether there has been formal feedback from the Ministry of Agriculture. As the bulletins are produced only for Ministry agreements, they are not accessible by others. In terms of the private sector, their willingness to pay for the information suggests that they derive utility from the products. Kazhydromet also provides a regular service to the train companies, but there is no feedback on this.

### 2.1.3. SERVICE/PRODUCT DELIVERY

The bulletins, reviews, and forecasts that Kazhydromet generates are emailed to the Ministry of Agriculture in Microsoft Word format. Due to email size restrictions, the resolution of figures, maps, charts, and graphics is lowered when sent to the Ministry. These lower quality versions are then faxed or emailed by the Ministry to the regional agricultural administrations. Transmission via fax results in further worsening of the quality of the images.[14] The weather and climate information is then delivered to farmers via various media (e.g., internet, radio, and television), via research institutes which review, process, and develop the information into products for farmers, and via Kazagroinnovation's extension network.

In terms of GIS capabilities, Kazhydromet currently is not able to generate its own maps due to the high cost of the ArcGIS software. The Meteorology, Climatology, and Agro-meteorological Departments are all interested in acquiring this or comparable software and building this capability within the organization.

## 2.2. GRAIN YIELD FORECASTS

The National Space Institute is one of four institutes that comprise the National Institute of Space Research and Technologies in Almaty. Within the National Space Institute, the Department of Space Monitoring Technologies employs 30 specialists whose work is focused on analyzing satellite data to evaluate and monitor changes in surface vegetation and water. Some of this work is implemented on an ongoing basis, and some of it is for discrete projects. Examples of the latter include assessments of surface water resources of Kazakhstan, fluctuation of the shoreline of the Caspian Sea, and changes in pasture cover.[15]

The Department prepares two products related to grain yields: 1) in-season estimates of anticipated grain yields and 2) a crop yield forecast based on a model that is calibrated using historical temperature and moisture data and oblast-level grain yields for the past decade. The in-season grain yield estimates are calculated as follows:

- Low and high resolution remote sensing data are used to determine biomass cover following planting and throughout the growing season – depending on the extent of biomass, the Department can detect cultivation efforts and estimate the area planted (and left fallow).
- The Department maintains a network of field stations planted with grain that are used to estimate the relationship between biomass cover and potential grain yields per hectare.
- The biomass cover data are combined with input from field stations to estimate total yield production. These estimates are updated throughout the growing season.

The Department also generates annual crop estimates before the spring wheat crop based on a model that correlates temperature and surface moisture anomalies at the beginning of the season to crop yields. The model has been developed and calibrated for more than a decade of data on oblast-level grain production (provided by the Ministry of Agriculture), temperature data from Kazhydromet, and moisture levels from

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[14] Baisholanov, S., 2013. *Agrometeorological Support of Agriculture of the Republic of Kazakhstan,* Report prepared for UNDP/USAID Project "Improving the Climate Resiliency of Kazakhstan Wheat and Central Asian Food Security." UNDP and USAID: Astana, Kazakhstan.

[15] Anderson, G., 2012. *Trip Report, Astana, Kazakhstan TDY Mission, November 26-December 7, 2012,* Memorandum prepared for CCRD. CCRD: Washington, D.C.

remote sensing data. . Grain yield information at a higher level of resolution than the oblast are available, but are considered proprietary information by the Ministry of Agriculture and thus not publicly available.

Probe data on the amount of water 100 cm below the surface is used to evaluate moisture availability for plants. Moisture values, which were originally a byproduct of trying to understand soil temperature, as water near the surface was found to hinder temperature signals, are used to determine wetness anomalies and understand the interaction between wetness and temperature. These relationships (e.g., whether conditions are hot and dry or cold and wet) have a greater impact on yield than each of the anomalies independently, and can be used to identify variations in yield, water resources, and irrigation supplies, as well as to monitor flood and drought.

## 2.3. CROP PRODUCTION VALUE CHAIN

The first link in the crop/wheat production value chain (see Exhibit 2) is critical in determining the mix of crops and the crop calendar for each crop. In making these farm-level decisions, farmers and farm businesses apply their entrepreneurial skills and assess readily available weather/climate information; production information (cultivation and harvesting technologies, and pest and disease control) and financial information (state subsidies, loans, taxes, input prices, crop prices, and markets/buyers for different crops). Other factors that determine cropping decisions include the farm's financial resources for purchasing seed, fuel, chemicals and paying for labor, and current capital assets (farm cultivation and harvesting equipment and machinery).

For wheat cultivation, there are two decisions taken each spring: 1) when to sow wheat seed; and 2) which variety or varieties of wheat to plant. In deciding when to plant, farmers in the survey indicated that they monitor soil temperature and moisture in the spring as well as weed emergence and growth rates. When the soil is clenched into a fist and falls apart, rather than forms into a ball, the soil is warm enough for sowing. However, the farmer may delay planting due to concerns about the potential for limited rainfall in May and June and the prospect of early season heat extremes during flowering which can significantly reduce yields.

The other consideration in deciding when to plant is expected weather during the period when grain is typically harvested. Most farmers lack the capacity to dry wheat and will plant earlier to avoid rainy weather toward the end of the harvesting period. Sowing later in the season also presents greater risk of non-sprouting due to dry soil as well as the possibility of not completing harvesting activities before the onset of the autumn rains due to late maturing crops. In addition, in excellent years, grain elevators may not be able to handle yields and prices towards the end of the season may be considerably lower than if the wheat is harvested and delivered to the grain elevators earlier.

The agricultural research centers in Shortandy and Kostanay issue general recommendations on sowing dates for wheat. The farmers surveyed perceive that these recommendations are quite general and do not account for weather/climate information and forecasts, but are based on technology and agronomy of wheat cultivation and maturation. In 2013, the Kostanay Scientific and Research Institute recommended the planting of wheat in the Kostanay region between May 20th and May 25th. In collaboration with CRW, the Kostanay Scientific and Research Institute conducted field tests for different planting dates (see Exhibit 6). In the field tests, wheat was planted May 5th, May 15th, May 25th, and June 5th. Wheat planted on the latter two dates showed much higher density of wheat than wheat planted on the two earliest dates. The results of these field tests were consistent with actual yields[16] recorded for the region for 2013: wheat planted between May 5 and May 15 resulted in yields between 0.85 and 1.24 tons/hectare, while wheat planted between May 25 and June 5 resulted in yields between 1.58 and 1.9 tons/hectare.

[16] While the field tests corroborated the recommendations on planting date for 2013, such experiments would need to be run for several years to assess the reliability of recommended planting dates. The onset of summer rains is a critical factor and in 2013, the rains arrived when it was needed for plant development, but in other years, the rains may come earlier or later.


**Figure 5: Wheat fields planted May 5th and June 5th at the Kostanay Scientific and Research Institute (Photos taken in August 2013)**

Decisions on which varieties of wheat to plant or whether to plant other crops involve several factors. In terms of which varieties of wheat to plant, farmers are aware that there are varieties of wheat that are more drought-resistant and/or heat-tolerant but in order to switch to these varieties, they would need information on the yields of other wheat varieties under different temperature and precipitation conditions, market demand and market prices, and access to alternative wheat varieties. They would also need to have enough confidence in the monthly/seasonal forecast to justify the switch from one variety of wheat to another.

With respect to switching to other grains or oilseeds, it important to note that wheat cultivation dominates all other spring crops planted in Kazakhstan. However, Kazakhstan is making progress in diversifying crop production away from wheat monoculture. In 2011-2012, Kazakhstan exported 135,000 tons of sunflower, soy, and rapeseed, and also cultivates linseed, pea, and safflower.[17] In addition to oilseeds' ability to fix nitrogen in the soil, they vary in their resilience to drought conditions in comparison to wheat; some oilseeds such as sunflower are more drought-resilient than the most popular wheat varieties in Kazakhstan. In discussion with farmers in stakeholder workshops and through the survey, we learned that most of the factors that have slowed crop diversification are non-climatic in nature: 1) lack of knowledge about the economics of alternative crops (production costs, yields, prices, buyers, and markets); 2) limited skills in cultivating alternative crops; 3) limited access to seeds for alternative crops; and 4) limited access to financing for purchases of machinery and equipment for specialized cultivation and harvesting. Information on potential grain yields and markets is important at subsequent links in the value chain. High estimates of grain yields can influence decisions on sales of stored grain and/or accelerated processing into flour to free up storage capacity in grain elevators. Low estimates of grain yields can inform decisions taken in maintaining reserves for domestic markets. Market information is valuable in understanding demand for wheat exports: Are crop yields in neighboring countries and other wheat exporting countries expected to be low or high? Do trading partners have adequate reserves? What market-clearing prices are likely to be in play in export markets?

## 2.4. WEATHER AND CLIMATE SERVICES: PROBLEM DIAGNOSIS

Farmers surveyed indicated that they are in need of reliable long-term forecasts (monthly, seasonal, and even annual) to help them adjust planting times and make decisions on crop diversification. Both the providers of forecasts (Kazhydromet and the National Space Institute) and the target users (farmers) recognize that meeting this need will require improving forecast quality and reliability as well as addressing underlying issues such as the existing network's inadequate coverage and equipment However, resolving the technical issues

[17] Meyriman, F.T., 2013. Oilseed Production in Kazakhstan: Status and Prospects. Presentation given at "CRW Field Day", Petropavlovsk, Kazakhstan.

alone will not be sufficient to ensure uptake by farmers. As the section on farmers' perceptions highlights, farmers' use of forecasts will be contingent on altering their view of the utility and reliability of forecasts.

### 2.4.1. FORECAST QUALITY AND RELIABILITY

The Kazhydromet and the National Space Institute have expressed dissatisfaction with the current quality and reliability of their forecasts. For instance, Kazhydromet's seasonal forecasts for temperature and precipitation only predict whether indicators for these variables will be below normal, normal, or above normal. Furthermore, Kazhydroment's seasonal forecasts have been determined to be reliable less than two-thirds of the time. Seasonal forecasts for temperature are reliable 60-62% of the time, and for precipitation 57-60% of the time.[18] The accuracy of agricultural meteorological forecasts is displayed in Exhibit 8. However, due to the obsolescence of crop varieties and farming practices, it is necessary to improve existing models and develop new ones for long-term weather forecasting and for crop simulations under different climatic conditions, according to a recent report on the state of agro-meteorological support to the agriculture sector in Kazakhstan.[19]

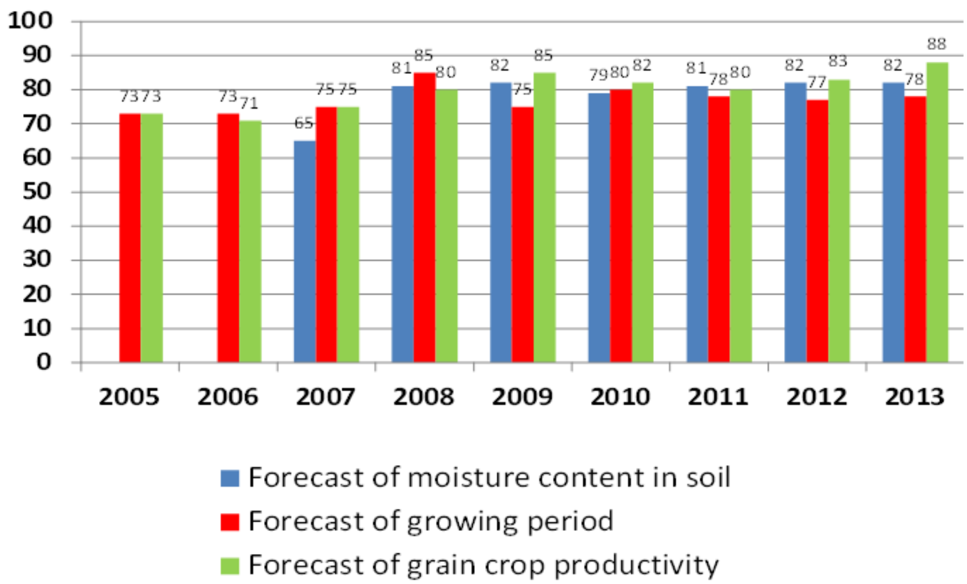


**Figure 6: Dynamics of agroforecast reliability**

Concerns about forecast quality and reliability were also expressed by the intended users of the information, including the Barayev Grain Institute and the Union of Farmers. The Grain Institute corroborated Kazhydromet's self-assessment of its monthly and seasonal forecasts. However, according to the Grain Institute, monthly forecasts are of limited use in making planting decisions. The Grain Institute noted that their researchers can more accurately determine when farmers should plant their crops based on field observations, and that Kazhydromet frequently recommended earlier planting dates than the Grain Institute.

The Union of Farmers made a similarly critical assessment of the reliability of available climate information. It added that the coverage of monitoring stations is too dispersed to be accurate for some farmers. For instance, two farms 100 km apart might have to rely on the same precipitation or soil moisture information, which

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[18] Akisharas, G., 2013, May. Long-term weather forecast management. Presentation given at "Roundtable on the Provision of information and Services on Weather and Climate", Almaty, Kazakhstan.

[19] Akisharas, G., 2013, May. Long-term weather forecast management. Presentation given at "Roundtable on the Provision of information and Services on Weather and Climate", Almaty, Kazakhstan.

could not adequately account for microclimatic differences. During in-country stakeholder consultations in February and March 2013, farmers also stressed the lack of reliable forecasts and information related to agro-meteorological conditions during the pre-seeding period, and the lag in the provision of meteorological data.

Kazakhstan currently lacks the capabilities to run the crop simulation models that are critical for understanding the potential impacts of climate change and variability on the wheat sector.

### 2.4.2. WEATHER AND CLIMATE INFORMATION QUALITY: FARMER PERCEPTION

The Survey results indicate that when farmers make decisions regarding planting times, their primary source of climate information is Kazyhdromet forecasts made available through mass media outlets (e.g., the Internet, TV, radio, newspapers, agricultural bulletins). They also draw on information accessed through regional workshops, recommendations from research institutes and extension centers, and farmer-to-farmer exchanges. Farmers also mentioned the local department of agriculture, the Ministry of Agriculture, Kazhydromet, Kazagromarketing, and Kazagroinnovation as sources of information.

Farmers neither regard highly nor trust meteorological and climate data, due to the lack of reliability of existing seasonal forecasts, and the lag-time in their provision. Moreover, they find the recommendations provided by the research centers and Agroinnovation's agricultural knowledge centers too general to be useful for their decision-making. While farmers may take account of these recommendations, they also rely on historical trends and practices and their own experience in determining the crop calendar. Surveyed farmers noted that they often use a simple soil test to determine if the soil is ready to plant – they take a handful of soil and try to squeeze it into a ball but if it crumbles instead of forming a ball, the soil is ready to be planted. In addition, farmers may be incentivized to plant earlier, even if it is not projected to be the optimal planting period for yield, in order to harvest and sell their grain crops before storage is exceeded in record harvest years. During the CRW field days in August 2013, it was observed that wheat fields between Kostanay and Petropavlovsk appeared to be of similar quality to the fields planted in Kostanay on May 5th, suggesting that they didn't follow the recommendations for planting date.

In terms of crop selection, farmers indicated in survey responses that because they perceive climate information to be unreliable, they do not use it to inform decisions about whether to diversify into production of non-wheat crops. They are unwilling to take on this risk given the quality of available forecasts. Other factors that keep farmers from diversifying are the lack of resources to purchase seeds for new crops and to acquire agricultural machinery and equipment for post-harvest processing of alternative crops. Farmers would like to be able to diversify eventually, and hope that they will receive support for this under Kazakhstan's Agribusiness 2020 Program.

Although surveyed farmers do not rely on climate information that is currently available, they acknowledged that they do not have the knowledge and understanding on how to adjust to changes in climate. Thus, information on long-term climate trends that is reliable and at appropriate scales could help farmers understand potential changes in climate as well as identify and implement appropriate response options. This will be particularly crucial for practices that require significant capital investments (e.g., seeds for climate-resilient grains) and/or long lead times.[20] Challenges associated with promoting use of improved information will include overcoming farmers' current perceptions of climate information as being of low quality and reliability. When asked whether they would use improved forecasts, farmers indicated that they would need to evaluate their effectiveness over a period of time as well as receive training for four to five years on adaptive technologies for spring wheat cultivation. These and other challenges as well as lessons learned are discussed in the final section.

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[20] CCRD, 2013. *Kazakhstan Stakeholder Consultations – Workshop Report, February-March 2013*. CCRD: Washington, D.C.

# 3. OPPORTUNITIES TO STRENGTHEN CLIMATE SERVICES

## 3.1. CLIMATE INFORMATION

### 3.1.1. WEATHER AND AGMETEOROLOGICAL OBSERVATIONS

The two major improvements that are needed with respect to observational data are expansion of the observation/monitoring network and digitization of historical data. Kazhydromet is pursuing funding to support expansion of the observation/monitoring network for meteorological and agmeteorological data. This expansion will provide better coverage of agricultural areas in terms of temperature and precipitation, soil moisture, and extreme events such as high winds, hail storms and heavy rainfall events. The additional data points will increase the precision of Kazhydromet's verification of extreme events for crop insurance claims and improve the reliability of the drought index (see Section 3.1.2)

Also, there is a considerable volume of historical temperature and precipitation data that has not been added to Kazhydromet's electronic database. As a result, the preparation of the monthly and seasonal forecasts requires staff to review hard copies when searching for historical analogs to current conditions for weather. The availability of this information in the electronic database would reduce the time required to search for analogs and prepare these forecasts. Support for digitization of historical data has been discussed but no action has been taken.

### 3.1.2. DROUGHT INDEX

Enhance drought analysis and forecast products:

- Review the current drought indicators used by Kazhydromet, and explore the possible use of the Standardized Precipitation Index (SPI)
- Install and provide training on the use of IRI software to construct the SPI and other drought indicators and to produce graphics to communicate drought forecast information to other Kazakh agencies and users
- Develop map rooms for the display of current drought conditions and SPI forecast values. These map rooms will be based on publically available precipitation data. At a later stage, the map rooms can be upgraded to include information for all meteorological stations in Kazakhstan. This will require Kazhydromet's development of digitized station data in a format compatible with the IRI software.

### 3.1.3. SOIL MOISTURE

Support to the National Space Institute will consist of three demonstrations:

- Analyze survey data of soil moisture at various depths that the National Space Institute collected in 2001 and historical data from SSMI for the same period to develop statistical relationships between wetness and soil moisture. Results will inform development of a system to automatically convert the

SSMI wetness index into an integrated soil moisture measure that farmers and extension agents can use to evaluate different planting dates and growing conditions. These measures can also help to predict crop yields.

## 3.2. WEATHER AND CLIMATE FORECASTING

In addition, the National Space Institute would like to improve their capacity to prepare seasonal forecasts and analyze longer term climate change impacts on agriculture, both inter-annual and decadal.

The parameters Kazhydromet and the National Space Institute are most interested in are temperature and precipitation during the upcoming growing season and those related to the selection of crops and the timing of sowing (soil moisture, warming of the soil, and snow melt)[21]. To facilitate this, support is currently being provided to Kazhydromet through the CCRD. Experts from the International Research Institute for Climate and Society (IRI) at Columbia University, Mr. Tony Barnston and Dr. Bradfield Lyon, will work with Kazhydromet to improve their monthly forecasts for temperature and precipitation and increase capacity to prepare drought forecasts. Mr. Alan Basist of WeatherPredict will provide the National Space Institute with demonstrations of an alternative method for forecasting drought, using the Special Sensor Microwave Imager (SSMI) technology.

Activities to support Kazhydromet are to include:

- Develop long-term statistical methods to forecast temperature and precipitation in Kazakhstan, with a focus on the wheat-growing regions of Northern Kazakhstan
- Introduce the use of a hierarchy of regression techniques to make statistical, probability-based forecasts
- Explore use of dynamical climate prediction models to make the seasonal forecasts
- Improve the forecast verification system to cover the currently used deterministic analogue system, and develop both the deterministic and probabilistic versions of the statistical forecast systems.

The work will initially be applied to publicly available gridded surface data sets over Kazakhstan; it could also be applied to Kazakh station data, if this information is made available by Kazhydromet.

## 3.3. CROP YIELD FORECAST

The National Space Institute has expressed a desire for assistance to improve their wheat yield forecast methodology as well as to model snow melt changes and correlate to spring soil moisture to produce better forecasts for the timing of sowing and potential for spring floods. They are also interested in analyzing fall soil moisture, humidity, precipitation, and temperature, and determining how this monitoring data can be applied in modeling and forecasting for the following spring.

- Test and integrate the SSMI wetness and temperature products with the Normalized Difference Vegetation Index (NDVI) signal from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite into a tool for monitoring growing conditions and making yield predictions. In contrast to the current MODIS-based greenness index, which requires remote-sensing planted vegetation coverage observations for reliable yield predictions, the new tool will be based on statistical analysis of wetness, temperature, and the greenness index for historical crop yields. It allow for earlier and more accurate wheat yield predictions.

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[21] Anderson, G., 2012. *Trip Report, Astana, Kazakhstan TDY Mission, November 26-December 7, 2012,* Memorandum prepared for CCRD. CCRD: Washington, D.C.

Under the project, assistance will also be provided to revise protocols for determining the information and services to be on Kazhydromet's and the National Space Institute's respective websites, and for sharing data among researchers in Kazakh institutions. Means to improve the presentation of this information online will also be considered.

- Work with grain institutes to better understand farmers' needs and the best delivery mechanisms to get them information in a timely fashion to support their decision-making, as well as to develop pilot products for farmers at the rayon level to increase the uptake and delivery of information provided by Kazhydromet. Possibly use this as a proof of concept to further support integration of Kazhydromet data into agricultural extension services.

# 4. CHALLENGES

The full value of improved forecasts will not be realized unless and until wheat producers and other sector firms such as exporters take actions based on their understanding of the information's implications for production and profits. No matter how good the improved forecasts are, lags in the use of the improved services can be expected. Before producers have confidence in the forecasts, they may need to see how improved forecasts compare to actual weather. As planting decisions are only taken once a year in the wheat-growing region of Kazakhstan, several seasons of improved forecasts may be required before there is significant use of the forecasts. Some producers may wait to see if other producers are using the new information in their planting decisions before they begin to use it. Agricultural extension centers and agents and other organizations can play an important role in making producers aware of the improved forecasts and sharing the results of decision-making by early adopters of the new information.

Once producers are aware of and have confidence in the improved forecasts, they will need to understand or interpret the information to determine how to adjust their planting decisions. Large commercial farms with staff agronomists may be able to interpret the new information and take decisions on planting. However, many smaller producers will look to the agricultural research centers and extension agents for recommendations on planting times and crop selection. Currently, staff at the agricultural research centers in the wheat-growing regions review all weather and agrimeteorological information and provide recommendations to farmers on when to plant wheat. To fully take advantage of the improved forecasts, particularly when drought seems likely, producers will need information not only on when to plant but also whether to plant common varieties of wheat or switch to drought-resistant wheat varieties, other cereals, oilseeds or other crops that may help producers sustain profits or minimize losses due to drought.

In addition to improved forecasts, producers will need cultivation information for alternative varieties and crops (yields, cultivation methods, chemical applications, harvesting technologies) and markets (prices, quality standards, buyers, etc.) in order to shift from wheat varieties grown in normal years. However, to act on the improved forecasts and relevant cultivation and market information, producers will need access to affordable drought-resistant wheat seeds, alternative cereal seeds, and oilseed seeds as well as appropriate cultivation and harvesting equipment, and agricultural chemicals.

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**U.S. Agency for International Development**

1300 Pennsylvania Avenue, NW

Washington, DC 20523

Tel: (202) 712-0000

Fax: (202) 216-3524

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